UNSTUCK

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Contents

Motivation

Hello and welcome! First off, a story.

I'm 16 years old, sitting in my introduction to physics class and we're learning about how if you throw a ball it goes up and down in the shape of a parabola. We look at a fancy slow motion video that shows the location of the ball every few frames, then traces it out, then it shows the equation.

$$d = \frac{1}{2}at^2$$

This equation is really simple to use, it's a couple of basic mathematical operations and as long as you know that the a in there is a constant you can look up, you're good to go. And the best part is, it just works. You can use this simple equation to *very* accurately predict how long you have remaining without pain when you drop a hammer from your hand that's destined for your foot.

I always kinda got into stuff like this, so when I got home I decided I'd do some experiments. I got one of my friends who had a video camera to bring it over, and we started dropping hammers (but not on each other's feet). We decided to be somewhat scientific about it, so we dropped the thing a few times to see how it fell, then we measured out exactly 1 foot, all the way up to as high as we could hold which was 7 feet and we recorded each height 3 or so times.

Our teacher had told us that $a = 32\frac{ft}{s}$, so we plugged it in and we decided to try to make it take exactly one second to hit the ground. Much to our surprise at the time, that means we only had to lift it up 16 ft; I remember we were both out of our minds because we swore it would need to be dropped from 32 ft up to stay in the air one second but that's what the equation says. He went outside; I went up to my second floor bedroom and hung the measuring tape out of the window. We marked off 16 ft exactly with a pen on the siding just below the window sill and dropped that hammer a half dozen times or so, trying our best to count out the time in our heads each time we dropped it.

We rushed back inside, loaded the video on my computer and started counting frames for each drop. The best we could find about the camera was that it had a framerate of 24 frames per second, which I recall seemed about right. Much to

our surprise, the time it took for the hammer to drop was not super consistent, but when you average out all the times, sure enough the times were very close to what the equation predicted. And most of all, we were both proven wrong in our own predictions about how far a hammer would drop in the first second!

I could barely sleep that night. I was so excited to actually use something we had learned that I couldn't wait to go back to school and tell everyone what we had done. When class finally arrives the next day we got there early and asked as many people as we could how far a hammer would fall in the first second, and most of them basically told us to piss off and stop acting like teacher's pets. BUT! a few played along *and every single one of them said 32 feet*, just like we had originally thought. Then our moment came, the teacher arrived.

We told the teacher what we had done, and we brought the paper with our recorded frames for each drop. He took a look over everything and said it was good work. All of that was well and good, but after all that, and seeing our measurements, one of the other kids declared absolutely no way this was right and then doubled down that if we had actually dropped a hammer from 32 feet high, it would take exactly one second to hit the ground.

One of the other kids, who was much more willing to believe our data, chimed in to our defense, "and how are you going to get 32 feet high exactly?", which was actually a really good point seeing as how I was hanging out a second floor window just to get to 16 feet. Then the clown popped in with "yea, why don't you just drop it out of an airplane?". The whole class giggled; the teacher started the lesson and that was that.

Then I went to sleep again, and when I woke up the next morning I had a thought… *what if we did drop the hammer out of an airplane?* I'm scared of heights so bad I once climbed back down a crowded ladder off the high dive at the local pool, kids calling me names each step of the way, to avoid feeling the sudden smack of the water against my skin. Getting up in an airplane with a window or a door open was not going to happen. But I thought, what if someone else did? What would I expect to happen? An airplane is pretty damn high up, so pretty much no matter what, you'd expect the hammer to be falling pretty damn fast when it hits the ground.

But isn't the same true for a human if they were to fall out of an airplane? Some idiots jump out of airplanes, but they don't seem to be going too fast when they hit the ground (seems like the theory of natural selection might be a failure as well). Clearly there is more to this story. Why does this equation work some of the time but not all the time? I took this question back to my teacher. His response was that here on Earth we experience drag, a force that opposes gravity in the case of jumping out of an airplane and that parachutes increase drag enough to slow a person down to a safe speed. Then he told me we weren't going to learn about drag for a couple of months but I was free to look ahead if I wanted to.

I expressed concern that what we were learning wasn't really useful and he told

me that this equation was indeed correct. He told me about a video from NASA where the astronaut David Scoot performed a similar experiment, dropping a hammer and a feather at the same time on the moon, and how they landed at the same time. I couldn't believe it, nor could I find the video in the school library (before the internet, y'all), but my dad told me later that evening he remembered seeing something like that on TV when he was a kid. He was certain he had seen it, and he was happily ready to confirm that the equation was correct.

I decided to flip ahead a few chapters and see how drag works, and whoaaaa….

$$drag = coefficient * \frac{density * V^2}{2} * reference\ area$$

I still don't understand all that today. There's another magic coefficient, only this time you can't just look it up. Density of what? What the hell is reference area? But good news, I am certain I can square a velocity and divide it by 2. And then the hardest part of all, how do use whatever this is with the other equation?

In simple terms, **I was stuck**.

Part 1: The Framework

Wherein we breakdown what it is to build software and why it's helpful to do so.

Chapter 1

What is software development?

This might seem like a strange place to start seeing as how you're already reading this book, but I think it's important that we're on the same page.

Problem solving is entirely about transforming data. As a software developer, your job is to implement transformations using a computer processor, and that's it. Your software takes some input, then generates some output. This is true from the macro level of building the products that your business sells all the way down to the micro level of executing individual processor instructions.

Most of the processors we write code for can only perform a couple hundred different possible transformations. It's incredible that we have so much software in this world, solving so many problems, and there are only a few hundred unique possible steps at the smallest level. It makes me think about how there are only a few dozen symbols in the English language and yet we can convey an incredible amount of knowledge through text. It makes me think about how there are only 118 known atomic elements which make up all the things we see and interact with in our daily lives.

We letters together into words, then words into sentences, sentences into paragraphs, paragraphs into chapters and chapters into books, books into libraries, and so on. Atoms combine to form compounds, compounds combine to form amino acids, amino acids combine to form protiens and protiens combine to form the abundant organic life that make this world so wonderful.

Everything that is big is made up of things that are small, and software is no different, it's a lot of small data transformations that compose much larger data transformations. When we think about problems we need to solve, we don't normally think about how to combine the smallest parts to build the big thing. If we're building a library we obviously don't need to think about how

to combine individual letters to make words and if we're hungry we sure as hell aren't going to be combining individual atoms to make spinach, in fact, we as a human race don't even have control over that. If all the spinach on Earth died out and all the seeds disappeared, the world would simply be without spinach from then on because we don't know how to combine individual atoms to make a spinach seed.

This is actually what makes software develop sort of unique compared to a lot of other common problem solving areas; in software development, it *is* the same thing all the way down, it's just transforming data.

- because of this, approaches which work at a very high level can also work at a very low level
- things have fundamental limits
- as you get higher, the requirements get less well defined

- At the end of the day your software compiles to something called machine language
  - machine language is effectively instructions on how to transform very small segments of data at a time
  - all we do is compose these small segments to achieve the full transformation we're after
  - processors available today contain

https://scienceillustrated.com.au/blog/science/ask-us-how-many-subatomic-particles-exist/

Chapter 2

Solving Problems

2.1 problem solving

2.2 writing code

2.3 debugging

Chapter 3

The Tools You Need To Get Unstuck

Now let's put this all together.

Part 2: Getting Unstuck

Wherein we look at some common ways in which we get stuck and discuss techniques for getting unstuck.

We're going to start by looking at a lot of problems related to performance, then we're going to move on to lots of ways we get stuck when looking at data.